University of Cincinnati

Date: 6/12/2015

I, Brian A. Eiler , hereby submit this original work as part of the requirements for the degree of Master of Arts in Psychology.

It is entitled:

What it means to be interact-able: A social affordance perspective

Student's name: **Brian A. Eiler**

This work and its defense approved by:

Committee chair: Rachel Kallen, Ph.D.

Committee member: Anthony Chemero, Ph.D.

Committee member: Michael Richardson, Ph.D.

19543

What it means to be interact-able: A social affordance perspective

A thesis submitted to the

Division of Graduate Education and Research

of the University of Cincinnati

in partial fulfillment of the

requirements for the degree of

MASTER OF ARTS

In the Department of Psychology

of the McMicken College of Arts and Sciences

by

Brian A. Eiler

B.A., University of Cincinnati, 2011

May, 2015

Committee Chair: Rachel W. Kallen, Ph.D.

Committee: Michael J. Richardson, Ph.D.

Anthony P. Chemero, Ph.D.

Abstract

Social interaction is not random. There is not a single prototypical social interaction; they are guided and functional. This begs the question, why do we interact with particular individuals initially and how to we maintain these interactions over time? How do we explain initiating social interactions and how do we explain interaction extended in time? Social-cognitive approaches to person perception argue that social cognition is the detecting particular types of person characteristics about others (i.e. sex and race) for use during interaction. Yet, this approach does not account for perceptual-motor processes like biological motion or coordination, which are known to impact social interaction broadly. The ecological perspective has been successful in explaining behavior in terms of perception and action. Here, social cognition is conceptualized as an emergent outcome of a nested system of agent-environment and agent-agent-environment perception action systems that realize behavioral opportunities for interaction—or said differently, social affordances. As both the social-cognitive and ecological approach have contributed to our understanding of initial interaction, this project combined these approaches to understand how movement and movement coordination relate to social cognition and a particular social affordance, interact-ability.

It was expected that biological motion would specify invariant person characteristics (i.e. sex and race) and movement coordination would be associated with greater prosociality and interact-ability. To test these hypotheses I employed a mixed design in which participants coordinated with kinematic information or kinematic information embedded in body structure and subsequently made target characteristic judgments. Results indicated that movement kinematics were necessary but not sufficient for sex detection, and that kinematics embedded in body structure afforded more accurate detection. Race was not detectable from biological motion. Movement coordination was also unrelated to interact-ability or detection accuracy for sex or race. Results indicated that both dynamic and structural properties are influential in determining the sex of an individual from their movement patterns. For race, results supported race as a social construction, rather than a biomechanical constraint. Coordination stability was conceptualized as a task constraint on social cognition. Theoretical contributions and implications are discussed in terms of interaction-dominant dynamical systems and complexity, as it relates to the study of social cognition more broadly.

Acknowledgements

I would like to thank my committee members. First and foremost, Dr. Kallen, for her unwavering support and guidance, along with Dr. Richardson, in the development of the current project. Dr. Kallen was exceptionally helpful in discussing the theoretical implications and impact on social cognition. Dr. Richardson was particularly helpful in designing the stimuli, helping with analyses, and ecological theory. Dr. Chemero had particularly helpful suggestions regarding affordances and interaction-dominant dynamics. I would also like to thank my family for their support, especially my partner Sarah.

Table of Contents

List of Figures

List of Tables

Introduction

Humans are embedded in social context. We have the potential to interact with others in a myriad of different ways: a smile in passing, a short conversation while standing in line at the grocery store, playing a game with friends, a performance review with a supervisor, a dance, repeated interactions with friends or a partner across various contexts, a marriage proposal, a surgical team performing an emergency procedure, etc. The interactions and tasks we perform together allow us to accomplish shared goals, as well as, establish and maintain various types of relationships. These interactions also vary in level of familiarity, complexity, purpose and extension in time. To interact, we must accurately detect and use social information. Successful detection of this information allows us to distinguish individuals and simultaneously provides feedback on how interactions unfold over time. We must also coordinate with each other such that tasks are accomplished effectively and appropriately. Yet, there is not a single prototypical social interaction. Moreover, interaction is not random. Interaction is functionally defined in that it is guided during ongoing production by some purpose (e.g. satisfying belongingness needs). This functional property of social interaction is what allows us to understand and organize the social world in terms of how others relate to us and how they facilitate our own actions.

The question remains, when and why do we interact with specific individuals, and what specifies particular types of interactions? Traditional social psychology suggests that social cognition, defined as an implicit and highly automatic information processing activity, guides ongoing behavior with others (Greenwald & Banaji, 1995). This approach has been valuable since social psychological research has clearly demonstrated that categorical person knowledge (e.g. race, sex), behavioral knowledge (e.g. relationship history, exposure, prior behavior) and dispositional characteristics (e.g. personality, attitudes, self-esteem) interact to impact sociality.

In this way, interactions are functionally adaptive behaviors that maintain stable and unique understandings of particular individuals in the service of effective and adaptive social exchange (Greenwald & Banaji, 1995; Macrae & Quadflieg, 2010; Kenny, 2004). Moreover, interactions overwhelmingly prosocial. While there are examples of situations where prosocial behavior is not observed (e.g. social loafing or diffusion of responsibility) or where prosocial behavior is not desirable (e.g. avoiding an attack), most often we seek out others. As such, a traditional social psychologist would make the general argument that we forage for others who are self-similar and possess qualities associated with pro-sociality (e.g. liking, attractiveness, trustworthy, etc.). This explanation also implies that interactions with others are guided by executive cognitive processes that match characteristics of others with our own since representation and cognition are assumed to guide and implement these procedures. As such, we must understand how we gather and integrate social knowledge.

One criticism of social cognition by executive control is that perception is given for free. Some have noted that we do not fully understand how perceptual processes influence social cognition because explanations rely primarily on cognitive representation to explain social interaction and behavioral prediction (Macrae & Quadflieg, 2010). In essence, social cognition has been reduced to disembodied cognitive processes whereby abstract representations have been given explanatory power in social perception. This is to say that representations impinge upon social perception during interaction, which may alter behavior as a function of representational content. Additionally, this approach does not sufficiently recognize the role of coordination in social cognition, even though movement and coordination directly impact outcomes of social interaction (e.g. rapport and liking) and have even been argued to be fundamental to social behavior more broadly (e.g. Hodges & Baron, 2007; Marsh, Richardson, & Schmidt, 2009; Richardson, Marsh, & Schmidt, 2010; Runeson & Fryholm, 1983).

As such, research that addresses how perceptual processes, including movement coordination, reveal social information during ongoing and dynamic social interaction with others is needed. Determining how these processes influence the varying level of intimacy and temporal nature of interactions themselves needed to if social cognition is in fact embodied and embedded. Furthermore, if movement coordination underlies social cognition more broadly, qualities of the coordination (e.g. stability) are likely to be systematically associated with social characteristics (e.g. accurate judgments of categorical or behavioral knowledge). By understanding how these processes produce detectable information that specifies different possibilities for interaction, we can conceptualize social cognition as an emergent outcome of a system in which perception, action and cognition are irreducible and dynamically intertwined, in line with ecological theories of human behavior (Gibson, 1979). Ecological theory (Gibson, 1979) also suggests that like other environmental objects, humans provide opportunities for action—affordances. Social affordances are defined as the possibilities for interaction provided by other conspecifics, in our case, other people. This conceptualization allows for a complementary way of understanding person perception and social interaction that can address the aforementioned gaps in our understanding of social cognition and interaction. In this way, social cognition is conceptualized as emerging from the mutual constraints and functional couplings amongst processes (cognition, action and perception), agents and environment, and agents themselves, rather than as a product of a social homunculus that guides our interactions with others.

The current project takes this approach to social cognition by examining two concepts related to the emergence of social cognition. Specifically, the current project examined one social affordance; “interact-ability,” and how nested levels of interact-ability are specified by information that relates individuals—movement coordination. Additionally, the current project identified what social knowledge is accurately detected about targets at zero acquaintance from movement kinematics and how this knowledge may be influenced by the stability or quality of interpersonal movement coordination. Overall, the role of coordination in the ongoing realization of interact-able and its impact on the accuracy of person perception will be addressed to establish the degree to which movement coordination underlies social interaction. In sum, this project was the first to address the social affordance “interact-ability” by examining how and what information is detected that specifies social knowledge and potential for interaction.

Social Cognition

The traditional understanding of person perception is that we develop interaction schema by integrating isolated information about ourselves, others, and behavioral actions in order to predict future behavior and make sense of ongoing social interactions (Macrae & Quadflieg, 2010). In support of this interactionist approach, Kenny (2004) has found that people utilize both categorical and behavioral knowledge to make judgments about others, and to predict how someone will act given a specific context. He also demonstrated that we integrate these two types of data to form individualized schema about individuals (Kenny, 2004). Here, categorical knowledge refers to nonverbal behaviors, appearance characteristics, stereotypes based on group membership, or other immediately detectable cues that place individuals into general classes. Behavioral knowledge is defined functionally in that behavioral knowledge imparts meaning to an individual’s actions. As such, there must be information we are sensitive to that conveys both types of social knowledge. Moreover, and because people able to accurately detect characteristics about strangers immediately (at zero acquaintance), it is reasonable to hypothesize that this information is available at zero acquaintance. Furthermore, because all potential relationships start at zero acquaintance and move toward extension in time, there may be information available at initial acquaintance that specifies when to interact with a person, or sets the initial trajectory that makes someone more or less interact-able over time.

Researchers have been interested in the type of judgments we make about others at zero acquaintance for some time. The predominant methodology used to study zero acquaintance is to have a participant view a short (between 200 ms and 5 minutes) sample of behavior, a "thin slice" that includes one or more behavioral channels (Ambady, Bernieri, & Richeson, 2000). A behavioral channel refers to the perceptual modality that contains information available for making judgments (e.g. a video with sound, a video without sound, a static picture, etc.). One goal of this paradigm is to identify the particular informational variables that people use to make accurate judgments about others. Thin slices have been shown to be sufficient for predicting a wide variety of behavioral and dispositional characteristics including: affect, personality traits, interaction motivation, social relationships between actors, bias, job performance, quality of relationship, gender, sexual orientation, and others (see Ambady, Bernieri & Richeson, 2000 for review). While static pictures or isolated audio are sometimes used in the thin slice paradigm, more often movement is one of the behavioral modes that produces information available for making target judgments. Yet, the particular movement patterns associated with accurate judgments of specific characteristics have yet to be established.

Interestingly, individuals who move more are more accurately and reliably judged than less expressive individuals (Ambady, Bernieri, & Richeson, 2000). Also, longer (4-5 minute) behavioral samples do not increase prediction accuracy compared to shorter samples between 200-400 ms, yet it is well known that as interaction time increases the utilization of behavioral knowledge compared to categorical knowledge increases (Ambady, Bernieri & Richeson, 2000). Together, these findings suggest that brief movement supplies some information that is integral to accuracy and reliability when forming person percepts, but additional information is gained from social interaction extended in time. Movement is hypothesized to provide this type of information. As such, it seems that initial movement dynamics are a good candidate for specifying categorical person knowledge, while coordination dynamics during interaction may specify another type of social information, behavioral knowledge, over time. Said differently, one hypothesis is that individuals may be sensitive to categorical person characteristics from movement alone, while coordination between individuals has the potential to specify another's behavioral characteristics, and their level of interact-ability for future contact. Support for this hypothesis would suggest that in both cases perception-action processes may underlie social cognition more broadly as suggested by various ecological and social psychological theorists (e.g. Hodges & Baron, 2007; Marsh, Richardson, & Schmidt, 2009; Miles, 2008; Richardson, Marsh, & Schmidt, 2010; Runeson & Fryholm, 1983).

Macrae and Quadflieg (2010) have argued that person knowledge is based on two specific perceptual determinants—invariant and variant cues. Invariant cues are not context specific, like sex, race, age, or other visual information, and are analogous to categorical knowledge described above (Macrae & Quadflieg, 2010). Variant cues, like behavioral knowledge, propagate social information and include dynamic signals like eye gaze direction and head-body orientation (Macrae & Quadflieg, 2010). Importantly, both invariant and variant person knowledge are integrated in order to maintain stable understandings of other conspecifics and to interact effectively (Macrae & Quadflieg, 2010). This perspective is similar to Kenny (2004), but differs in how explanatory power is given perception and cognition. Kenny (2004) gives more importance to computational processes that integrate different types of knowledge, while Macrae & Quadflieg (2010) argue that perceptual-motor processes are more fundamental to social cognition. Importantly, the hypothesis that we are sensitive to information that specifies both categorical and behavioral person knowledge is consistent with both perspectives. Extending the idea that perceptual-motor processes underlie social cognition (Macrae & Quadflieg, 2010), it could be that general categories are initially detectable from movement, and with continued interaction movement coordination provides feedback on the degree to which interaction can be maintained or extended in time. Furthermore, movement coordination may facilitate accuracy during initial detection of categorical and behavioral characteristics.

Although social psychologists often contend that initial person perception is a function of schema that allow us to speed up the information processing processes used for the behavioral prediction that facilitates social interaction, an alternative for studying social interaction and person perception is provided by affordance theory (Gibson, 1979), discussed in the next section. In this case, categorical/invariant knowledge detected at zero acquaintance is hypothesized to be specified by movement kinematics alone. Similarly, extended social interaction is the realization of the social affordance interact-ability, which is detectable from information generated by the target-perceiver system (movement coordination) that specifies interaction behaviors by revealing prosocial characteristics that facilitate successful and efficient social exchange.

Affordances and Social Affordances

Affordances are directly detectable behavioral possibilities that are specified via information that relates animal and environment in terms of an animal's action capabilities (Gibson, 1979). Because affordances are directly perceived and specified by information, cognitive mediation and information processing are unnecessary—behavioral options are not deduced; they are realized (Gibson, 1979). This means that affordances do not rely on disembodied and abstract cognitive processes to explain behavior. Instead, an affordance is both subjective in that it is detected from the perspective of particular animal embedded in a particular environment, yet is also objective in that information arises from available energetics that can be detected by an animal (Baron, 1979). For the current project, social cognition is defined as an ongoing affordance detection process in which movement provides the necessary energetics that specify particular behavioral opportunities for interaction. Humans provide affordances for other humans. While Gibson did not distinguish between affordances provided by objects versus conspecifics, he did suggest the concept of a "mutual affordance," the affordances provided by other humans, rather than being exclusive to objects (1979). He also argued that humans provide the most interesting and rich opportunity for affordance research (Gibson, 1979).

As previously stated, a social affordance is a possibility for interaction and is different from other affordances in particular ways. A social affordance must be mutually defined as a relation between conspecifics, which detected and dynamically realized. Thus, a social affordance is irreducible to a single relation between agent and environment, although these relationships certainly do not cease to exist and are not subjugated with respect to social affordances. This means that the proper unit of analysis for a social affordance is the agent-agent-environment system in which information still lawfully specifies behavioral possibilities for interaction. To be clear, a social affordance is not the detection of an individual affordance in coordinated time and space by multiple animals (c.f. Baron, 1979). As stated by Gibson (1979), affordances are nested, thus it is reasonable to hypothesize that for complicated behaviors like social interaction, agent-agent relationships at the dyadic or group level are embedded in agent-environment interactions at the individual level. By adding the word "social" in front of affordance, this means the system actualizing the affordance is a perception-action system at the interpersonal level. This seems to imply a different level of affordance for dyads in which agent-agent relations specify behavioral possibilities that drive interaction—social affordances. This idea has been captured by research investigating interpersonal synergies in which individuals form a self-organized system capable of coordination on various tasks in which behavior is an emergent property of the entire system, such as rhythmic movement (Riley, Richardson, Shockely, & Ramenzoni, 2011) and dialogue (Fusaroli, Rączaszek-Leonardi & Tylén, 2014).

That coordination precedes control is not novel (Bernstein, 1967). Furthermore, it is well recognized that specific types of coordination will depend on context, with general coordination principles remaining similar across time and across tasks (Turvey, 1990). This means that rather than an actor simply detecting behavioral possibilities from an object with static (or very slowly changing) properties, a social affordance like interact-ability is characterized by a reciprocal information generation process whereby co-actors both produce and detect information that specifies possibilities for interaction, in coordinated time and space. Here, information specifies particular opportunities for interaction and drives future interactional states by relating co-actors to each other. This is not in place of individual relations with the environment for each actor, but in addition to, or nested with, those real possibilities for action. This begs the question, what information specifies particular social affordances like initial interact-ability or approachability, and does this information constrain person perception?

Because a social affordance is defined as an opportunity for interaction there are many affordances that one might provide another. It is likely that what makes someone interact-able is not dichotomous, but rather scales in time and intimacy. A person might be "hello-able," "smile-at-able," "date-able," "friend-able," "cooperate-able," or infinitely many other degrees of interact-able. Yet for any of these higher-order social affordances that involve repeated interaction across time, one must have a certain level of interact-ability that must be realized repeatedly. If one is not initially interact-able, one is never date-able, friend-able, teammate-able, etc. Yet, coordination is by definition a process that occurs because of non-singularity and coupling across individuals, and as such, one may not be coordinated with another actor prior to interaction. This means there must be a different source of information, not coordination, that specifies initial interact-ability, or characteristics that signal that one has properties that make them a good candidate for interaction.

In light of the discussion above, there must be both a source of information that specifies both initial interact-ability as well as information that specifies interact-ability over time. While movement kinematics may specify initial categorical knowledge about others (discussed below), it is coordination between agents that is hypothesized to continuously specify and maintain interact-ability. This means that coordination should also relate to more positive evaluations of characteristics that would signal potentially positive interaction partners or prosociality. As the study of coordination dynamics has been used extensively to understand joint action, many contemporary researchers have suggested that our understanding of coordination and movement dynamics could be extended to the study of social affordances and social interaction more broadly (Baron, 2007; Miles, 2008; Richardson et al., 2010; Schmidt & Richardson, 2008; Warren, 1984). Yet, empirical validation of what information makes someone interact-able initially or over time has yet to be established. Fortunately, an extensive literature on the relationship between movement and social interaction can be used to link initial person perception and level of interact-ability from initial acquaintance to more complex social interactions across time.

Social Cognition, Biological Motion and Interact-ability

Movement is important to the current project in two ways. First, because categorical knowledge about others often impacts social interaction quite extensively, and in light of the literature on thin slice judgment, it is possible that movement dynamics may provide information that directly specifies categories that are highly relevant to social cognition (e.g. sex and race). Second, because social affordances are, by definition, agent-agent relations, and movement coordination has been demonstrated to characterize many interpersonal interactions, movement may specify either target characteristics (e.g. likability, status, etc.) or potential quality of interaction over time, or both. Because coordination specifies a mathematical relationship between co-acting agents and an individual's movement is visually detectable, both are potential candidates for specifying categorical and behavioral knowledge about others, as well as, interact-ability. One promising area of research that provides a methodology for testing this informational specification is biological motion. For the present discussion, biological motion will be used to refer to movement produced by a human.

First described by Johansson (1973), point light displays have been used to identify the type information available in biological motion and how we use this information quite broadly. A point-light (PL) display is a dynamic video that reduces whole body movement to bright markers placed on major joints. Point light displays retain kinematic information but eliminate all other sources of person knowledge by rendering body structure invisible and isolating visual information such that only potential sole source of information comes from joint movements represented by moving dots on a screen (Johansson, 1973). This is important because it allows us to distinguish characteristics that are informationally specified by movement alone from those that may be specified by other types of information (e.g. visual cues like skin complexion).

Furthermore, because movement is determined by kinematics (mechanics of motion) and motion is governed by dynamics (properties of objects that are causally involved in the course of movement) kinematics reveal the underlying dynamics, which specify properties of some object. As such, humans perceive potential opportunities to interact with objects by detecting dynamic properties that specify what can be done with or from some moving entity, including other humans (Runeson & Frykholm, 1983). This is to say that because dynamics are lawfully related kinematics, social affordances and person knowledge could specified by information available in movement because movement provides information that implicates the underlying dynamics of social interaction. If this is the case, socially relevant knowledge should be perceptible from movement, which prior research has demonstrated for particular movement patterns like gait.

Kozlowski and Cutting (1977) have demonstrated that the sex of a walker could be detected from a dynamic point light display. Cutting and Kozlowski (1977) found that information in gait allowed subjects to categorize strangers and friends accurately. Gait dynamics also impact trait impressions of power, happiness, and youthfulness, masculinity, easygoingness and approachability (Montepare & Zebrowitz-McArthur, 1988). Furthermore, the social affordance "attack-able" is also kinematically specified by gait (Gunns, Johnston, & Hudson, 2002). Research that examines how other types of social behaviors (e.g. dancing, playing games, etc.) specify categorical or behavioral characteristics that impact interact-ability (e.g. race, personality, liking etc.) is needed. This could provide support for the hypothesis that an individual's movement implicates socially relevant information and specifies initial interact-ability, which can explored by repeated interactions that produce information, coordination, used for maintaining interaction over time. As such, interaction tasks in which people coordinate with each other should both increase the accuracy of judgements we make about others' characteristics, if coordination facilitates extended interact-ability. This is in line with the idea that we are better at predicting the actions of those we interact with more often because we have more accurate categorical and behavioral knowledge about our interaction partner. Furthermore, coordination may specify more intimate interactions because we do not find individuals we coordinate well with to be unpredictable or awkward. Because some types of person knowledge (e.g. sex, age) are likely linked to differences in kinematics or biomechanical constraint, while other differences (e.g. race, individual differences) may be more likely to be linked to differences in an individual's dynamics, it is important to determine how these categorical and behavioral constraints are specified. It could be the case that only biomechanical constraints are kinematically specified, or it could be the case that movement gives us a sampling of the underlying dynamics that operate at more complex levels of functioning, like social interaction. As such, determining which variables are specified by an individual's movement kinematics and which variables are specified by movement coordination between actors is a goal of the current project.

Related to coordination, we do not often seek out negative or difficult interactions with others. This means that stable coordination should increase pro-social behavior and positive interaction outcomes, especially if it is the case that coordination specifies continual interact-ability and higher levels of intimacy via more accurate person knowledge and greater predictability. In line with this, Miles, Nind and Macrae (2008) showed that coordination impacts rapport such that rapport was highest when gait patterns were coordinated and stable. Even when coordination is measured or manipulated at an extremely coarse scale (e.g. when people choose the same bet as each other), coordination increases positive evaluations of another person's intelligence, self-similarity, and like-ability (Abele & Stasser, 2008). Miles, Griffiths, Richardson and Macrae (2010) have hypothesized that coordination may be a way to regulate interpersonal relationships in that those who we like are imitated, while those we do not like are not. This would seem to suggest that disruptions of coordination specify not-interact-able and cause individuals to disengage, as is the case with the observed interferences of bodily synchrony that occur during disagreements (Paxton & Dale, 2014). Together, this motivates the hypothesis that coordination can both increase the degree to which we make positively evaluate others, as well as, indicate that we should interact more often, or in more intimate ways, with those we coordinate with well.

This idea is not new to social psychologists. Mimicry is synonymous with interpersonal synchrony and coordination (Lakin, Jefferis, Cheng & Chartrand, 2003) and is defined as the copying of postures, mannerisms, gestures, facial movements or other's behavior (Chartrand & Bargh, 1999). It is bidirectionally and positively associated with affiliation and rapport and functions to adaptively initiate and maintain positive social relationships, like coordination (Lakin, Jefferis, Cheng & Chartrand, 2003). Kouzakova, Karremans, van Baaren and van Knippenberg (2010) found that for those who were not mimicked during an interaction, current relationship evaluations were moderated by increased belongingness needs. As such, they argued that lack of mimicry during interpersonal interaction hampers sense of belonging (Kouzakova, Karremans, van Baaren and van Knippenberg, 2010). Furthermore, it is difficult to decrease behavioral mimicry although the goal to disaffiliate seems to disrupt coordination (Chartrand & Lakin, 2013).

As such, one way to unify the ecological and social psychological perspectives on how individuals synchronize with each other, is to assess how coordination impacts interpersonal variables associated with pro-sociality and mimicry, by assessing how coordination stability is associated with co-actor judgements of categorical knowledge (e.g. sex and race), positive social characteristics (e.g. like-ability, trust, rapport), and intentions to interact in more intimate situations (e.g. sharing a meal or introducing to friends).

Current Project

Overall, the research described above suggests three things. First, that movement is information that specifies target characteristics (e.g. sex, traits) and social affordances (e.g. attack-ability, approach-ability). Second, that coordination is associated with pro-social behavior and often characterizes positive social interactions. Finally, that coordination may serve to specify continual interaction by facilitating accurate person perception, which allows for additional opportunities for interaction. These three findings motivate the hypothesis that movement underlies social cognition because movement produces kinematic information that reveals dynamic person knowledge and coordination facilitates accurate person perception and specifies interact-ability.

Yet, it is unclear how biological motion is used to make accurate predictions about targets in terms of person knowledge, and what target characteristics are detectible from movement kinematics in more ecologically valid tasks beyond gait. While various types categorical and behavioral knowledge can be detected directly from biological motion (e.g. stranger/friend, sex, etc.), to date, no studies have addressed whether race or initial evaluations of interact-ability are specified by kinematics. Moreover, no studies have assessed whether coordination specifies ongoing possibilities for interaction or if coordination facilitates more accurate, or more positive, predictions of target characteristics, as suggested by previous research. As such, the proposed project will address these gaps in the literature and test the hypothesis that movement underlies social cognition and potential for interaction.

Hypotheses

Hypothesis 1. Invariant knowledge (sex and race) will be detectable at zero acquaintance from kinematic information alone (point light displays) and kinematic information plus body structure (depth array), but accuracy will be greater with additional body information.

Hypothesis 2. Coordination stability will be positively related to performance accuracy in detecting invariant person knowledge.

Hypothesis 3. Coordination stability will be positively associated with interact-ability, such that more stable movement coordination will be associated with increased likelihood of interaction.

Hypothesis 4. Coordination stability will be positively associated with pro-sociality and more positive judgements of target characteristics.

Method

Participants

Participants included forty (n = 40) undergraduate students from the University of Cincinnati, a majority of whom were female (72.5%) and Caucasian (82.5%). Participants ranged in age from eighteen to forty-five (M = 21.18, SD = 5.78). Partial course credit was given in exchange for participation. All subjects were right handed and free from any known neurological or musculoskeletal disorder and had normal or corrected to normal vision.

Materials

Actor Movements.

Stimuli (described below) were created from eight human actors who volunteered to have their movements recorded to be used in the experiment. Four volunteers identified as Caucasian (two male/two female) and four identified as African-American/Black (two male/two female). All actors were between 5’9” and 6’0” tall, of similar body type, and around the same age (18-26 years old). Actors were instructed to produce three different types of movements: jumping jacks, marching in place, and side-to-side shuttle steps. Their movements were recorded using the Xbox Kinect at 21 frames/second. During the recording procedure, all actors wore a skin tight latex suit and a beanie style hat in order to eliminate any information that might be used to identify sex or race (i.e. hair length/style and clothing) and standardize the stimuli. Actors produced each movement type three times continuously for two minutes. The middle 15 seconds of the second trial for each actor was used to create all stimuli used in the experiment. Actors were unaware of which movements would be used and were instructed to produce each movement as naturally as possible. No other instructions were given for any of the movements other than the shuttle step, in which actors were instructed to move side to side in a four step pattern (two steps to each side). The resultant movement time series included the x, y, and z position of sixteen joint markers used to create experimental stimuli. Both point light and depth array displays used the same movements for each actor and each movement type. This means that the exact same movements were used for both stimulus types for each actor and movement, such that the only difference between the two was how the information was displayed (dots vs. image) and available information (kinematics vs. kinematics + body structure).

Point Light Displays.

A total of twenty-four point light displays were created and included one sample of each of the three movement types for each actor (three movements x eight actors). Point light displays were displayed on a blue background with a red dot representing each of the joint markers, with the head dot slightly larger than the rest of the markers (see Figure 1). A computer program was created to display the movements at the sampling rate that also height normalized each actor to fit the screen. Height normalization maintained the proportionality between joints and simply fit the display to the computer monitor. The point light displays retained kinematic information while removing all other sources of actor information beyond movement. All displays were 15 seconds in length.

Depth Array Displays.

A total of twenty-four depth array displays were created and included one sample of each of the three movement types for each actor (three movements x eight actors). Depth array displays included an outline of the body structure in a black and white image (see Figure 1). These displays were played via a computer program that played the series of images recorded by the Xbox at the sampling rate. Depth array displays were not normalized in any way. The depth array displays retained the same kinematic information as point light displays but also included visual cues to depth (as can be seen in the room outline) and body structure of the actor. No other social information was available (e.g. complexion). All displays were 15 seconds in length.

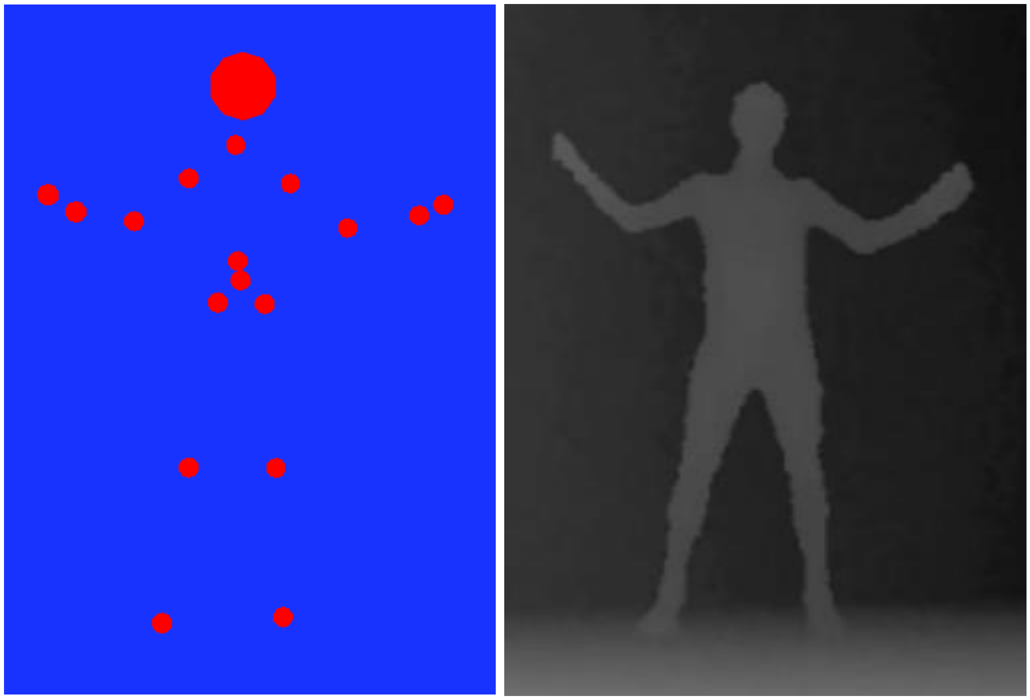

Figure 1. Example point light display (left) and depth array display (right).

Demographic Questionnaire.

Participants completed a demographic questionnaire on an iPad using SurveyGizmo online software (SurveyGizmo, 2015). Demographic information collected included: age, sex, race, Big-Five personality assessment (Gosling, Rentfrow, & Swann Jr., 2003), and self-reported assessments of participants' sociability, friendliness, and feelings of power, mood, and status assessed on a five point Likert-type scale.

Stimulus Questionnaire.

Participants completed a questionnaire on an iPad using SurveyGizmo online software (SurveyGizmo, 2015) to make target judgments. Participants indicated the sex, race, and age of the stimuli. For sex and race, a forced choice design was used (male vs. female; white vs. black). For age, a range was used (18-30) in which participants selected one age to indicate their prediction. Next, they indicated how much they agreed or disagreed with statements (five point Likert-type scale) assessing behavioral/variant knowledge about the stimulus. These included: liking, attractiveness, approachability, ease of cooperation, self-similarity, rapport, sociability, friendliness, power, mood, and status. Last, they indicated how likely they would be to interact with the stimulus by answering the following questions on a five-point Likert-type scale from disagree to agree: *I would feel comfortable approaching this person, I would say hi to this person if I passed them in the hallway, I would avoid eye contact with this person, I would ask this person for directions if I was lost, I would make small talk with this person, I would want to get to know this person better, I would introduce this person to my friends.*

Procedure

The current project employed a mixed design with stimulus type (point-light and depth array), sex and race of actor, and movement type as within subjects variables, and coordination vs. no coordination as a between subjects variable. The primary dependent variables were target judgements of sex, race, dispositional characteristics and interact-ability. Participants entered the lab under the guise of participating in an experiment to help design avatars for a virtual reality dancing game. The experiment was first described to participants upon entering the lab who were told they would be making several types of judgements about two different characters. They were told that their responses should be their first impression of the character, but to be as honest and accurate as possible so that our avatars would be as lifelike as possible. No other instructions on the composition or characteristics of the stimuli were given. Participants were randomly assigned to the coordination or no coordination group. The no coordination group was instructed to stand about 5 feet from a 50” computer screen while viewing the stimuli. Participants in the coordination group were told they should “Coordinate with the stimulus so that you do the same thing at the same time as the avatar on the screen" and were located the same distance from the computer monitor as those in the no coordination group. In all cases, participants were told which type of movement would be shown, counted down from three to start the video, and filled out the stimulus questionnaire immediately following each stimulus. Participants viewed stimuli in randomized blocks so that each participant viewed all of one type of stimulus (either depth array or point light) and subsequently viewed all of the other type of stimulus. Within stimulus type stimuli were randomly presented to each participant. Participant movements were recorded by the Xbox Kinect at 21 frames per second on each trial for analysis. Upon completion of the experiment participants were debriefed and thanked for their time.

Results

Sensitivity to Sex and Race

We hypothesized that invariant information (sex and race) would be detectable at zero acquaintance from kinematic information alone (point light displays) and kinematic information plus body structure (depth array), but accuracy would be greater in the depth array condition. Results partially supported this hypothesis. We calculated d-prime (*d*') values for sex and race in both the point light and depth array conditions, which is a measure of signal to noise sensitivity. First, we tested these values against chance levels (*d*' = 0 at chance) to determine if participants were able to accurately detect sex from point light displays and depth array displays.

For sex, results of the one-sample *t*-tests indicated that participants were able to detect sex above chance levels when movements were produced by men in both the point light, $t(37) = 2.334$, $p = .025$, and the depth array, $t(37) = 20.368$, $p < .001$, conditions. Similar results were obtained for detecting sex when movements were produced by a woman. Results of the one-sample *t*-tests indicated that participants were able to detect sex above chance levels when movements were produced by women in both the point light, $t(35) = 3.634$, $p = .001$, and the depth array, $t(37) = 21.346$, $p < .001$, conditions. Furthermore, results of a paired samples *t*-test indicated significant differences in *d*' in the point light condition compared to the depth array condition for sex detection for male movements, $t(33) = -12.603$, $p < .001$, and female movements, $t(33) = -13.909$, $p < .001$, such that participants were more accurate in the depth array condition in both cases. Figure 2 summarizes these results.

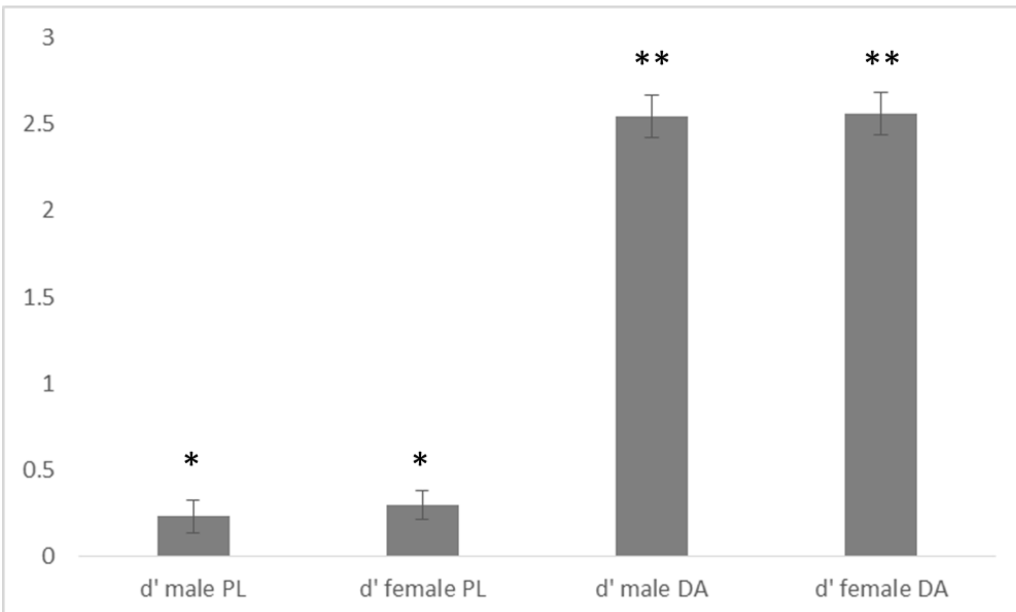

Figure 2. Kinematic specification of sex as a function of condition. * $p < .05$, ** $p < .001$.

For race, results did not support our hypotheses. Participants were unable to detect race above chance levels in the point light or the depth array conditions when movements were produced by either a white or black actor. There was no statistical difference in *d*' values between point light and depth array conditions. Figure 3 displays these results.

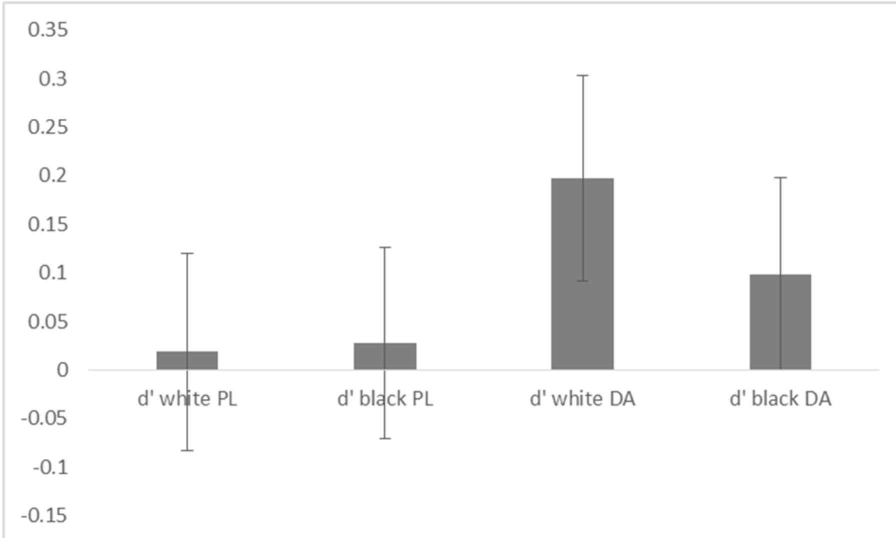

Figure 3. Kinematic specification of race as a function of condition.

Coordination Stability

All of our other hypotheses were related to the quality, or stability of the movement coordination. As such, we calculated a measure of stability, cross-spectral coherence (COH), to quantify the degree to which participants and stimuli movements were synchronized. COH ranges from 0 in the case of completely non-synchronized systems, to 1 in the case of perfectly synchronized systems. As participants were positioned such that they were facing the stimuli we calculated COH for joints on opposite sides of the body in all cases (e.g. participant right hand to stimulus left hand). We chose the following joints for analysis. For jumping jacks, we used the average of the left and right wrist joints' COH in the z-plane (up and down). For both marching and shuttle steps we used the average of the left and right hip joints' COH in the x-plane (left to right). As such, we were able to collapse COH values across different planes and different movement types in order to maximize power. We do not report differences in the coordination compared to the no coordination group here, as this did not seem to be the appropriate control since coordinating and not coordinating were fundamentally different tasks. We also believe this is valid since there were no differences in sex or race detection as a function of coordination grouping. Instead, we examined how the stability of coordination, as measured by COH, impacted the variables of interest.

For point light stimuli, there was no impact of coordination stability on sex or race detection. Specifically, there was not a significant difference in COH values on correct trials, compared to incorrect trials for either sex detection (p = .88) or race detection (p = .49). Results on depth array trials were consistent with this finding such that there were no significant differences in COH for sex detection (p = .783) or race detection (p = .727). We also calculated bivariate Pearson correlations between coherence and *d*' values on a subject by subject basis and did not find a significant association for either point light trials or depth array trials (all *p*s > .05). Combining all trials types also showed a similar pattern of results in that there were no differences in COH values on correct compared to incorrect trials for both sex (p = .106) and race (p = .565). COH values were also not associated with any individual difference variables including ratings of interact-ability (all *p*s > .05). As such, our second, third and fourth hypotheses were not supported.

Finally, we examined matched pairs for sex and race to determine if differences in coordination stability emerged as a function of same-sex or same-race pairs. There were no significant differences. Same-sex and opposite sex pairs were statistically indistinguishable in both the point light (p = .77) and depth array conditions (p = .865). As for same-race and different-race pairs, the same pattern emerged. There were no differences in coordination stability as a function of racial pairings in either the point light (p = .709) or depth array (p = .936) conditions.

Additional Data Analyses

We also conducted several other data analyses. Based on exit interviews and observational notes from experimental sessions, we thought it could be the case that there were differences in how well participants were able to coordinate with different actors. As such, we used the stimulus actor as a grouping variable in a series of one-way ANOVAs to examine differences in variant knowledge judgments, interact-ability and coordination stability.

Results indicated significant differences in some variant characteristic judgments, but not others, as a function of stimulus actor. Considering both point light and depth array judgements we found no differences in liking, attractiveness, approachability, rapport, sociability, friendliness, mood, and all measures of interact-ability. For cooper-ability, self-similarity, powerfulness, and status there were differences across actors, but these differences did not show any patterns related to sex or race. For coordination stability we found that the actor mattered. There were significant differences in the stability of the coordination as a function of the actor that produced the movement ($p < .001$). Although all actors had high COH levels, meaning they were all easy to coordinate with, there were differences amongst them (see Figure 4).

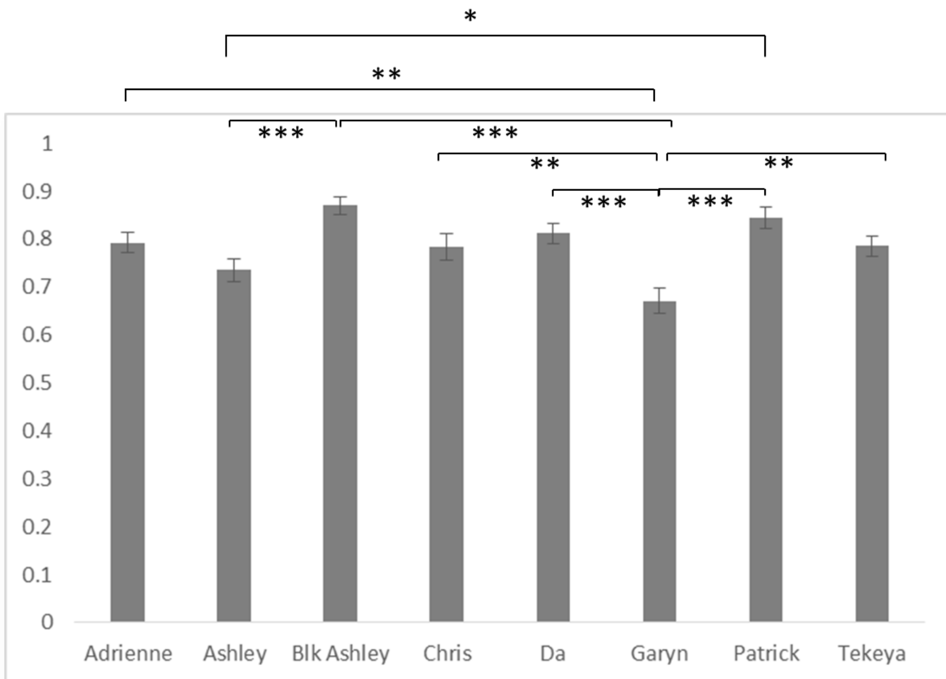

Figure 4. Differences in COH as a function of actor. Significance values are Bonferroni post hoc tests. * $p < .05$, ** $p < .01$, *** $p < .001$

Because of the differences in coordination stability as a function of actor, we also thought it would be wise to examine the extent to which individuals actors producing a specific movement type were associated with variant behavioral characteristics and interact-ability. As such, we looked at the bivariate Pearson correlations between COH and judgements of behavioral characteristics and interact-ability as a function of actor and movement type. COH was associated with different characteristics for different actors and movement combinations. There did not seem to be an overall pattern to the relationships. Table 1 displays significant correlations between variant characteristic judgements and COH for the point light display condition only. Table 2 displays significant correlations between interact-ability and COH for the point light display condition only. Table 3 displays significant correlations between variant characteristic judgements and COH for the depth array condition only. Table 4 displays significant correlations between interact-ability and COH for the depth array condition only.

Actor/Movement	Liking	Attractiveness	Approachability	Cooper-ability	Self-similarity	Rapport	Sociability	Friendliness	Power	Mood	Status
Adrienne (J)	-.44*					-.46*					
Adrienne (M)	.46*		.54*	.493*							
Adrienne (S)											
Ashley (J)											
Ashley (M)											
Ashley (S)					.52*						
Black Ashley (J)											
Black Ashley (M)											
Black Ashley (S)											
Chris (J)											
Chris (M)											
Chris (S)											
Dan (J)											
Dan (M)											
Dan (S)		.47*			.49*						
Garyn (J)											
Garyn (M)											
Garyn (S)	.59**			.49*		.67**					
Patrick (J)											
Patrick (M)											
Patrick (S)					.53*						
Tekeya (J)											
Tekeya (M)		.52*									
Tekeya (S)											

Table 1. Correlations between COH and judgements of variant characteristics for point light display condition. *$p < .05$, **$p < .01$

Actor/Movement	Comfort Approaching	Say Hi in Hallway	Avoid Eye Contact	Ask for Directions	Make Small Talk	Want to get to Know	Introduce to Friends
Adrienne (J)	-.5**						-.491*
Adrienne (M)							
Adrienne (S)			-.48*				
Ashley (J)							
Ashley (M)							
Ashley (S)							
Black Ashley (J)							
Black Ashley (M)							
Black Ashley (S)							
Chris (J)							
Chris (M)							
Chris (S)							
Dan (J)							
Dan (M)							
Dan (S)					.46*		
Garyn (J)				.49*			
Garyn (M)							
Garyn (S)	.50*					.54*	
Patrick (J)			-.63**				
Patrick (M)							
Patrick (S)							
Tekeya (J)							
Tekeya (S)							
Tekeya (M)							

Table 2. Correlations between COH and judgements of interact-ability for the point light condition. $*p < .05$, $**p < .01$

Actor/Movement	Liking	Attractiveness	Approachability	Cooper-ability	Self-similarity	Rapport	Sociability	Friendliness	Power	Mood	Status
Adrienne (J)	-.44*										
Adrienne (M)											
Adrienne (S)	.45*		.66**	.57**			.57**	.55**			
Ashley (J)											
Ashley (M)											
Ashley (S)											
Black Ashley (J)									-.51*		
Black Ashley (M)											
Black Ashley (S)											
Chris (J)										-.59**	
Chris (M)								.50*			
Chris (S)											
Dan (J)											
Dan (M)											
Dan (S)											
Garyn (J)	.49*	.57**		.61**	.58**	.61**	.53*			.66**	
Garyn (M)									-.53*		
Garyn (S)							-.46*				
Patrick (J)											
Patrick (M)											
Patrick (S)											-.52*
Tekeya (J)											
Tekeya (M)											
Tekeya (S)											

Table 3. Correlations between COH and judgements of variant characteristics for the depth array display condition. *p < .05, **p < .01

Actor/Movement	Comfort Approaching	Say Hi in Hallway	Avoid Eye Contact	Ask for Directions	Make Small Talk	Want to get to Know	Introduce to Friends
Adrienne (J)							
Adrienne (M)			.45*		.45*		-.47*
Adrienne (S)		.49*			.46*		
Ashley (J)			-.54**				
Ashley (M)							
Ashley (S)							
Black Ashley (J)							
Black Ashley (M)				.51*			
Black Ashley (S)							
Chris (J)							
Chris (M)							
Chris (S)							
Dan (J)							
Dan (M)							
Dan (S)							
Garyn (J)		.46*			.45*	.51*	.61**
Garyn (M)							
Garyn (S)							
Patrick (J)							
Patrick (M)							
Patrick (S)							
Tekeya (J)							
Tekeya (S)							
Tekeya (M)							

Table 4. Correlations between COH and judgements of interact-ability for the depth array condition.
*$p < .05$, **$p < .01$

Discussion

Human beings rely on their ability to gather social knowledge from observing other humans' actions (Blake & Shiffrar, 2007). The current project tested the hypothesis that biological motion and movement coordination underlie social cognition and interact-ability. We sought to demonstrate that movement kinematics were sufficient to set an initial interaction trajectory because invariant person characteristics known to impact interaction would be detectable from movement, specifically someone's sex and race. Furthermore, we hypothesized that when people coordinated their movements the stability of this coordination would not only positively impact characterizations of someone at zero acquaintance, but would also be associated with increased interact-ability, or likelihood to interact. To test these hypotheses we had participants view short videos of joint movements and body movements, which were produced by black and white, male and female, actors. Participants coordinated with these videos or simply watched them, and subsequently made judgements on a variety of person characteristics, as well as, rated their likelihood to interact with them in various situations. In general, we found little support for our hypotheses, which will be discussed in terms of extant literature below. We will also discuss theoretical implications of this research and situate this conversation in the context of movement and social interaction more broadly.

Sex

Our first hypothesis was that sex would be detectable from kinematic information alone, and that the addition of body structure would increase this sensitivity. Our results were consistent with this hypothesis. In this sense we were able to replicate prior research on sex detection from biological motion, and extended this literature by demonstrating the robustness of this phenomenon for movements beyond gait (Kozlowski & Cutting, 1977; Mather & Murdoch, 1994; Sumi, 2000; Troje, 2002). In the point light condition participants were able to discern if movements were produced by a male or female actor at levels above chance. In the depth array condition, sex recognition sensitivity was drastically increased—participants identified sex with nearly perfect accuracy. This implies while kinematics alone are insufficient to characterize sex detection, which deviates somewhat from existing literature on the topic (as discussed below), although it should not be understated that we were able to replicate prior research on sex detection from kinematic information broadly.

Race

To date, no studies have addressed the extent to which biological motion underlies race categorization. Understanding how we determine the race of a potential interaction partner is important because the assumed race of an individual can have a significant impact on social interaction, a discussion of which is beyond the scope of the current project. We found no evidence that race can be detected from biological motion. Even the addition of body structure did not impact sensitivity. This is likely because there are not biomechanical constraints on race in the same way there are biomechanical constraints on sex. Said differently, white and black individuals have the same variation in body type across race as variation within their respective races. Our lack of support for the kinematic specification of race may explain why this effect does not show up in the literature on biological motion—the effect may not exist. As such, those interested in determining how race is specified should look to potential cues beyond movement.

Interact-ability

We hypothesized that not only would coordination show similar effects to other interpersonal coordination and mimicry studies in terms of person knowledge, but also that coordination would specify the social affordance interact-ability. The current project did not find support for either of these predictions—coordination stability was unrelated to person perception or interact-ability in any systematic way. This means that interact-ability may not be specified by coordination, at least not initially. Overall, and discussed in greater depth below, we come to the general conclusion that coordination, at least for our task, functions as a context specific constraint on social cognition. While interpersonal movement coordination is often associated with pro-sociality, it does not seem to be required for interact-ability, as demonstrated by the current experiment. This seems reasonable in that we cannot initiate an interaction via coordination because without interaction there is no opportunity to coordinate. That being said, it does seem reasonable that coordination may serve as an indicator that we are doing something pro-social or are interacting in a specific way (e.g. affiliating), although we did not find any direct evidence of this in the current study. Future research should address this possibility specifically. It also seems reasonable to consider other possibilities for information that specifies interact-ability, or coordination in other modalities outside of movement (e.g. similar status, clothes, vocal tones, etc.). Perhaps it is also a good idea to consider that interact-ability may be too broad. It could be the case that hello-able, high five-able, walk-with-able, etc. are more likely candidates for social affordances. This is also consistent with typical affordance research in which affordances tend to be reduced to specific activities (e.g. pass-through-able, climb-able, grasp-able, etc.). Miles (2008) is a good example of how this work should be continued as he demonstrated the affordance of approachability varied as a function of facial expression and sex.

Theoretical Implications

Our findings implications for sex and race detection, as well as, for the study of social affordances and with respect to coordination. Each will be discussed below in turn.

Our results have clear consequences for the study of how sex is perceived from biological motion. While point light displays have provided great insight into the degree to which movement is responsible for perceptions of sex, it is also clear that we do not encounter walking dots in our everyday lives. Kozlowski and Cutting (1977) were first interested in investigating the structural invariant that participants used to identify sex from a point light walker. They demonstrated that "roughly speaking, any joint is sufficient and no joint is necessary for the recognition of a walker's sex" (Kozlowski & Cutting, 1977, p. 578). Furthermore, they did not make any claim as to whether differences arise from biomechanical or socialization processes, only that accuracy appears to hover around 70%. Sumi (2000) also found similar results in that when walkers were viewed as eight point displays, sex identification was around 80%. These results are consistent with sensitivity to sex in the point light condition in the current project.

However, if kinematics alone were sufficient to discriminate sex, one would hypothesize a non-significant increase in recognition from the point light display condition to the depth array condition. We did not find this to be the case. Participants were almost universally perfect in sex recognition in the depth array condition. Accuracy was above 95% in almost all cases. Furthermore, when using principal components analysis to identify which joints contributed to the overall variability of movement we found that for all movements there were 2-4 factors that included nearly all joints across all actors which accounted for around 90% of the movement variability. While it is true that all kinematic information available in the point light display is also available in the depth array display, if kinematics were sufficient there should be a smaller margin. These results do not contradict with Kozlowski and Cutting (1977), but do seem to indicate that joint structure in relation to each other is likely more important than individual joint movements themselves. Another way to say this is that kinematics do not tell the whole story.

This begs the question, does structural body information simply add to accuracy or does it drive recognition?

In line with a kinematic account of sex recognition, Mather and Murdoch (1994) sought to demonstrate biomechanical differences as the source of differences in walking patterns between sexes. They found that sex discrimination was mediated by these biomechanical differences, specifically lateral body sway in the shoulders and hips (Mather & Murdoch, 1994). Furthermore, they argued against a structural account because they determined that participants were able to discriminate the sex of a computer generated walker based on a fraction of a step cycle from a single joint. Their results are problematic for two reasons in light of the current study. First, their stimuli were produced from computer generated movements, not from real people. While this serves to manipulate the amount of sway for any joint and pragmatic this approach suffers real problems of validity. In the current project, the movements of real men and women are displayed, thus predictions of sex can be compared to biological sex, rather than artificially varied sway imposed on shoulder or hip joints. It is true that men and women have varying degrees of sway, but arguing that we recognize the sex of real people from sway based on eight participants characterizations of artificially enhanced gait patterns is not scientifically satisfying.

In addition, they argued that kinematics were more powerful than structural information in discriminating sex (Mather & Murdoch, 1994). This claim is based on a manipulation of a "male torso" and a "female torso" in combination with varying permutations of sway. Again, they found that sway was more important in participants identifying sex rather than torso shape. This is in direct opposition to the current project in which we demonstrated convincingly that body structure drastically increases sensitivity to sex. This result is likely due to the fact that in our experiment there was an objective measure of sex because movements were produced by real men and women, rather than manipulations of joint movements being characterized as male or female as in the Mather and Murdoch (1994) study. This also implies that information beyond that which is produced by movement impacts sex detection, but that kinematics have some explanatory power, or influence, in shaping our judgments of sex.

Several other studies have demonstrated that dynamic properties of point light walkers are most important, rather than dynamics embedded in body structure. For example, Cutting (1978) found that shoulder movement and hip movement were sufficient for detecting sex. Troje (2002) demonstrated that exaggerating male and female movement patterns produced by real actors impacted sex detection such that when structural information was not present, performance was affected minimally, while in cases where dynamic information was not present sex became nearly undetectable (Troje, 2002). Furthermore, eye tracking has demonstrated that observers focus mostly on the hips when judging sex from point light displays (Troje, 2002). It seems that there is a general agreement that dynamic information is highly important, even if not sufficient for sex detection from point light displays of gait. As such, rejecting kinematic specification of sex out of hand seems unwarranted.

Yet, some research indicates body structure has explanatory power in how we detect sex. For example, Runeson and Frykhom (1983) found that participants were still accurate at detecting sex from point light displays when actors were told to depict motions that were typical of the opposite sex. This means that simply acting like a different sex does not disguise the embedded dynamics imparted by biomechanical differences in body structure. Furthermore, some have argued that point light displays do not capture the correct variable used for discriminating sex from motion, which is likely the size and shape of the waist in relation to hips.

Importantly, this ratio is embedded in the overall body structure because it includes the waist, which does not have an associated principal movement joint. Because of this difference in male and female morphology, and the fact that point light displays eliminate this source of information, our results could be explained by the fact that the depth array contains this information. Johnson and Tassinary (2005) found support for this claim by manipulating the waist to hip ratio and asking participants to judge the sex and corresponding masculinity/femininity of walkers and found that judgements of sex were more accurate when waist to hip ratios were consistent with the actual gender of the walker. Furthermore, McDonnell, Jorg, Hodgins, Newell and O'Sullivan (2007) created virtual walkers with sex neutral gait patterns and applied these walking patterns to male and female figures. They found that neutral walking patterns were perceived as normal (meaning sex congruent) only when paired with body morphology. In other words, a sex neutral walk in a male figure is perceived as male and a sex neutral walk in a female figure is perceived as female—morphology takes precedence over joint kinematics (McDonnell et al., 2007). Additionally, Johnson and Tassinary (2005) found primacy for body shape in perceiving sex from biological motion. They demonstrated that visual scanning of point light walkers was concentrated on the waist and hip region, but this was attenuated by pre-specifying the sex of the walker (Johnson & Tassinary, 2005).

For determining sex from biological motion it seems there are clearly influences of both dynamics and structural properties. In fact, Troje (2002) has developed a mathematical model of gait patterns that discriminates sex as a function of scaling a parameter alpha, which incorporates both structural and dynamic properties. In the current project we found evidence that supports the necessity of both kinematic and structural properties to explain sex discrimination from biological motion. We replicated prior work on sex detection from point light displays and extended this work to include accuracy increases with the addition of body structure. Furthermore, our research was novel in the fact that we demonstrated that this claim is not isolated to gait patterns. It seems that for other movement patterns (i.e. jumping jacks and side-to-side shuttle steps) joint kinematics must also be paired with structural body information to determine the sex of an individual from their movement patterns. It is also clear that body structure drastically increases accuracy of sex detection and is more ecologically valid. Humans are moving bodies with embedded dynamic properties, but are not reducible to joint kinematics alone.

As such, it is important for researchers to be careful about claims that exaggerate the relative importance of kinematic variables, at least with respect to detecting sex from biological motion. This means that while movement is important, how movement is embedded in a body structure that is also moving is likely more relevant to the discussion. This also implies that movement research, especially research that is confounded by knowledge of the sex of participants or coordination pairs, should either address the issue of sex differences or control for them. Furthermore, it seems that same-sex and opposite-sex pairs are an unlikely confound for most research activities as the current project demonstrated that these pairs seem to coordinate in similar manners.

As for the kinematic specification of race, we found no evidence that race can be detected from movement kinematics or movement kinematics embedded in body structure. This implies that race is cued by some other informational variable, most likely complexion. Future research should examine the specific informational variables that specify assumptions about race. Our results are consistent with race as a socially constructed concept in which biological or biomechanical differences do not underlie differences between those that identify as Caucasian and those that identify as African-American (Smedley & Smedley, 2005). Our research is also consistent with research indicating that racial groups are not genetically discrete, and fuels the idea that historical context and cultural context are more likely constraints on racialized differences in behavior (Smedley & Smedley, 2005). As such, movement research that ignores race as a potential confound is probably safe from criticism unless the research includes manipulations or dependent variables also known to be impacted by race, or assumptions about race. More interestingly, race should be conceptualized as a possible constraint on the perceptions of synchrony or coordination (c.f. Lumsden, Miles, & Mccrae, 2012).

There is a long history discussing the relationship between coordination and social interaction. In the ecological psychology literature interpersonal coordination and joint action have been studied at length, with some discussion of how coordination impacts interaction outcomes and person characteristics. Within the social psychology literature, mimicry and behavioral synchrony have been posed as highly influential features of social interaction that relate to outcomes. Interpersonal synchrony has been claimed to underlie many social interactions and outcomes and even selected as an evolutionary principle for social cohesion, yet these results may often be exaggerated, overstated, or simply worded to reflect an exaggerated importance placed on coordination.

For example, Oullier, de Guzman, Jantzen, Lagarde and Kelso (2008) argue that biological motion plays a key role in social coupling. Their article is even entitled *Social coordination dynamics: Measuring human bonding* (Oullier et al., 2008). Yet, there was no measure of social anything, no scale reflecting bonding, no questions asked about how much the other individual is liked or how attractive they were, etc. What they call social memory is in fact nothing more than hysteresis, a phenomenon known to characterize complex systems and repeated behaviors. In sum, the human bonding they claim to underlie interaction is nothing more than a phase relationship in a finger tapping task. The tendency to not revert to an intrinsic baseline frequency after visual coupling between two individuals instructed to tap together, is described as the *social memory effect* (Oullier et al., 2008). As we found no systematic pattern that related coordination and self-similarity, affiliation, or rapport, it seems that our results are more likely to accurately reflect that role of coordination in true social bonding.

Similarly, Hove and Risen (2009) have argued that interpersonal synchrony increases affiliation. They argue that synchrony promotes self-other overlap (in neural representations) and the outcome is affiliative tendency. In this case correlations between the likability ratings of a confederate who tapped in coordination with a metronome alongside a participant were moderately higher than ratings of likability when the confederate did not synchronize with the participant (Hove & Risen, 2009). To assess directional causality, a second experiment was conducted such that participants were asked to rate the experimenter's clarity and friendliness while giving instructions, a supposed proxy for likeability. They also manipulated the degree of coordination. Results indicated that in the synchrony condition the experimenter was liked more than in the asynchrony condition. A closer examination of these results indicates that ratings of likeability were quite high in both the synchrony condition ($M = 6.87$) and the asynchrony ($M = 5.91$) and the effect size was moderate ($d = .74$). The authors noted they controlled for baseline levels of likeability and mood, and it is possible that participants liked the experimenter more simply because they were doing a synchronous task, but not because of the coordination between the two individuals. Thus, in a third experiment they tested this idea by having the experimenter sit in the room but not tap along with participants. They found that likeability ratings were not different as a function of condition, yet all likeability ratings in the third experiment were larger than in the first two. Hove and Risen (2009) do not discuss this issue. It could be the case that the difference in likeability in the second experiment was due to the fact that the experimenter was making the tapping task more difficult by being out of synch with the participant, which would decrease likeability. It is also a stretch to argue that likeability and affiliation are proxies for one another.

The criticism that these results are likely confounded is supported by the current project. We did not find an association between coordination stability and likeability, affiliation, cooper-ability, or rapport. If interpersonal synchrony drives affiliation as suggested by Hove and Risen (2009) one would expect systematic relationships in at least one, if not all, of the aforementioned social variables. Since we did not, this suggests that there was something intrinsic about the experimenter in the Hove and Risen (2009) studies. An alternative, though unlikely explanation, is that there is something intrinsic to tapping that causes affiliation, however this is not a satisfying explanation since affiliation is associated with many other behaviors beyond finger tapping.

Similarly to research on interpersonal coordination, research in social psychology has also given explanatory power to mimicry and behavioral matching. Chartrand and Lakin (2013) have defined behavioral mimicry as when two or more individuals do the same behavior at the same time. This is also the definition of synchrony. It should also be noted that mimicry has been defined with a temporal lag between producer and mimicker (e.g. Bailenson & Yee, 2005). In a set of seminal studies, Chartrand and Bargh (1999) argued that behavioral matching is automatic and related to pro-sociality. First, they had participants interact with a confederate, by choosing a series of stimulating pictures, in which the confederate was trained to shake their foot or rub their face. They found that participants also shook their foot or rubbed their face unconsciously, and more often, when the confederate did so. In the next experiment they asked participants to rate how smooth the interaction was and how much they liked the confederate. In this experiment the confederate either mimicked or adopted neutral postures during the interaction. Again, those that were mimicked liked the confederate more and thought the interaction was smoother (Chartrand & Bargh, 1999). This initial line of studies has led to a wealth of research on mimicry and behavioral matching, most of which concludes that coordinated behavior is associated with increases in prosociality.

In the current project, we explicitly manipulated synchrony exactly quantified the degree to which individuals mimicked each other via coherence and for specific body segments (i.e. hips and wrists). There are several aspects of mimicry that our study failed to replicate despite the methodological rigor and precise quantification of mimicry present. For example, Bourgeois and Hess (2008) found that in-group members are more often mimicked than outgroup members. We found that for both same-sex and same-race pairs this was not the case. This was even true for trials on which the sex and the race of the participant was correctly predicted. As such, our results are not consistent with the idea that in-group members coordinate more with each other than with outgroup members. On the contrary, social perceivers judge synchrony to be less in pairs of synchronized hand movements when skin tones are dissimilar despite the fact that coordination was held quantitatively constant (Lumsden, Miles, & Mccrae, 2012). This means that there is something about the subjective experience of the coordination that must underlie these differences incorrectly attributed to quantitative differences in synchrony. It could be the case that synchrony at a coarser scale (e.g. having the same name predicts greater mimicry, Gueguen & Martin, 2009) is more impactful. Either way, because many studies have demonstrated mimicry to be positively associated with affiliation there is likely a link between behavioral coordination and affiliative tendency (e.g. Cheng & Chartrand, 2003; Lakin and Chartrand, 2003).

In general, it has been proposed that mimicry is exhibited to create affiliation and rapport during social interaction. In the Gueguen and Martin (2009) and Chartrand and Bargh (1999) studies, mimicry is defined as doing a similar behavior to someone on a videotape. Furthermore, mimicry studies often boil down to self-similarity. For example, Burger, Messian, Patel, del Prado, and Anderson (2004) found that participants who were similar in birthday, name or body type to the confederate were more likely to act pro-socially toward the confederate. Heider (1958) proposed that these similarities create an association between individuals, which creates an enhanced positive perceptions of others, because of our desire view ourselves in a positive light. Again, self-similarity is seen as the driving force behind mimicry's positive enhancement of targets. Even shared opinions can lead to more mimicry (Van Swol & Drury, 2006) and those who are viewed as more attractive are also mimicked more often (van Leeuwen, Veling, van Baaren, & Dijksterhuis, 2009). A criticism of all of these studies is that they do not quantitatively measure the degree to which people mimic, or coordinate, with each other. Another, but related problem with these studies is that mimicry is defined inexactly. In the current study, we were able to quantitatively measure the degree to which in people mimicked each other via coherence. We produced evidence that contradicts the claims made of many mimicry researchers. One potential reason for this contradiction is many mimicry studies are based on unconscious mimicry. Ours was not. Participants were explicitly told to coordinate with one another.

Interestingly, this effect of intentionality also shows up in the interpersonal coordination literature. For example, people tend to synchronize with each other when they have an existing positive relationship (Miles, Griffiths, Richardson, & Macrae, 2010) or with whom they want to have a positive relationship with in the future (Miles, Lumsden, Richardson, & Macrae, 2011). Furthermore, if one has self-disclosed to an individual (a process that increases rapport, liking, trust, etc.) they tend to coordinate more (Vacharkulksemsuk & Fredrickson, 2012). Finally, simply having a prosocial orientation during interaction can facilitate interpersonal coordination (Lumsden, Miles, Richardson, Smith, & Macrae, 2012).Yet in these examples, coordinating with an individual was explicit in the instructions of the task. This raises the issue of how coordination relates to task social task constraints, how social cognition emerges.

Conclusion

We set out to demonstrate that social cognition was an affordance detection process in which movement underlies person knowledge by producing information that guides interaction both initially and over time. Although we did not find overwhelming evidence to support this argument, our results do provide evidence that social cognition may emerge from the functional couplings and constraints that arise during interactions themselves. As such, the emergence of coordination during social interaction may revolve around intentionality and goal direction. For example, if the goal is affiliation or prosociality, or if there is an existing positive relationship amongst individuals, coordination may emerge from these constraints during a task like social interaction (c.f. Van Orden, 2010).

As such, we argue that social cognition emerges from an interaction-dominant dynamical system (IDDS) that includes co-actors embedded in social and historical context. A self-organized IDDS is defined as a system lacking an executive controller in which interactions amongst components best describe the behavior of the overall system and demonstrate emergent behaviors (Van Orden, Kloos & Wallot, 2011). More importantly, cause is distributed and heterarchical in an IDDS such that long time scales disproportionately constrain faster timescales and processes are organized from slow to fast in terms of their rates of change (see Figure 2; Eiler, Kallen, Harrison & Richardson, 2013). In the context of social cognition, slowly changing processes (e.g. one's biological sex; the social construction of race) may constrain faster changing processes (e.g. initial interact-ability) which constrain even more rapidly changing processes (e.g. movement coordination during interaction). In the current study we found that virtually static processes (i.e. the sex of an individual) were most accurately judged when rapidly changing movements (kinematic information) were situated within more slowly changing contexts (body structure). Furthermore, we did not find evidence that race, a slowly changing cultural process, was specified by a more quickly changing process of biological motion. We also found coordination to be unrelated to sex or race detection. This makes sense in light of the idea that coordination operates at a much faster time scale than do an individual's particular movement patterns, which have been constrained by prior life experience. It seems that for characteristics that operate on a slower time scale than interpersonal movement coordination, there were no effects of coordination. This is exactly what would be predicted if social cognition emerges from a self-organized IDDS. Another way to say this is that the functional couplings and constraints amongst these processes themselves impact the emergence of one's perception of others. In other words, social cognition is an emergent outcome of a process in which social knowledge emerges continuously in time. In this conceptualization, our results are consistent.

Yet, coordination was associated with target judgements, but differently as a function of individual actors' movements. In this sense, coordination operated as a constraint on person knowledge. This is also predictable if social cognition emerges from a self-organized IDDS in that the more slowly changing task constraints (i.e. intention to coordinate with an actor's movement and corresponding quality of coordination) may impact knowledge of an actor's properties, which operate at a time scale less extended in time. This implies that coordination may emerge as a function of the constraints (i.e. goal) of the interaction itself, as previously mentioned. This is consistent with a research indicating that task goals impact the type of coordination that emerges between individuals (e.g. Richardson, Harrison, Kallen, Walton, Eiler, Saltzman, & Schmidt, 2015; Schmidt, Nie, Franco & Richardson, 2014).

Although coordination was related to some aspects of person perception, we did not find that coordination specified interact-ability over time. One reason we failed to demonstrate this effect may be that interact-ability is too broad a social affordance. Another, and more likely reason, is that coordination is, by definition, a relationship defined by more than one individual. Interaction is also defined as a non-singularity. As such, it is highly unlikely that two individuals would be coordinated in their movement patterns prior to interaction, if this is even possible at all. Most likely, information exists that specifies initial interact-ability via positive pro-social characteristics, but it is definitively specified by the stability of motor coordination. This does not mean that coordination is unimportant, but rather that coordination is just another component of social interaction, important when the task goal requires coordination to be completed successfully, as mentioned above.

In sum, our research indicates that movement does not specify the social affordance interact-ability, neither initially nor via coordination for interactions extended in time. Yet, we found evidence that social cognition emerges from the nested processes of constraint that operate concurrently during person perception. Finally, we conclude that research on human movement, interpersonal coordination, and mimicry are insufficient for a complete characterization social cognition and that researchers must include other processes and information to fully explain what humans afford other humans.

References

Abele, S. & Stasser, G. (2008). Coordination success and interpersonal perceptions: matching versus mismatching. *Journal of Personality and Social Psychology, 95*(3), 576-592. DOI: 10.1037/0022-3514.95.3.576

Ambady, N., Bernieri, F.J., & Richeson, J.A. (2000). Toward a histology of social behavior: Judgmental accuracy from thin slices of the behavioral stream. In *Advances in Experimental Social Psychology Vol. 32* (Mark P. Zanna, Ed.), 201-271.

Bailenson, J.N. & Yee, N. (2005). Digital chameleons: Automatic assimilation of nonverbal gestures in immersive virtual environments. *Psychological Science, 16*(10), 814-819. DOI: 10.1111/j.1467-9280.2005.01619.x

Baron, R.M. (1979). Ecological approaches to understanding human crowding. *Journal of Population, 2*(3), 235-258. DOI: 10.1007/BF00972539

Baron, R.M. (2007). Situating coordination and cooperation between ecological and social psychology. *Ecological Psychology, 19*(2), 179-199. DOI: 10.1080/10407410701332106

Bernstein, N. (1967). *The coordination and regulation of movements*. London: Pergamon Press

Blake, R. & Shiffrar, M. (2007). Perception of human motion. *Annual Review of Psychology, 58*, 47-73. DOI: 10.1146/annurev.psych.57.102904.190152

Bourgeois, P. & Hess, U. (2008). The impact of social context on mimicry. *Biological Psychology, 77*(3), 343-352. DOI: 10.1016/j.biopsycho.2007.11.008

Burger, J.M., Messian, N., Patel, S., Del Prado, A., & Anderson, C. (2004). What a coincidence! The effects of incidental similarity on compliance. *Personality and Social Psychology Bulletin, 30*(1), 35-43. DOI: 10.1177/0146167203258838

Chartrand, T.L. & Bargh, J.A. (1999). The chameleon effect: The perception-behavior link and social interaction. *Journal of Personality and Social Psychology, 76*(6), 893-910. DOI: 10.1037/0022-3514.76.6.893

Chartrand, T.L. & Lakin, J.L. (2013). The antecedents and consequences of human behavioral mimicry. *Annual Review of Psychology, 64*, 285-308. DOI: 10.1146/annurev-psych-113011-143754

Cheng, C.M. & Chartrand, T.L. (2003). Self-monitoring without awareness: Using mimicry as a nonconscious affiliation strategy. *Journal of Personality and Social Psychology, 85*(6), 1170-1179. DOI: 10.1037/0022-3514.85.6.1170

Cutting, J.E. (1978). A program to generate synthetic walkers as dynamic point-light displays. *Behavior Research Methods and Instrumentation, 10*(1), 91-94. DOI: 10.3578/BF03205105

Cutting, J.E. & Kozlowski, L.T. (1977). Recognizing friends by their walk: Gait perception without familiarity cues. *Bulletin of the Psychonomic Society, 9*(5), 353-356. DOI:

Eiler, B.A., Kallen, R.W., Harrison, S.J., & Richardson, M.J. (2013). Origins of order in joint activity and social behavior. *Ecological Psychology, 25*(3), 316-326. DOI: 10.1080/10407413.2013.810107

Fusaroli, R., Rączaszek-Leonardi, J. & Tylén, K. (2014). Dialog as interpersonal synergy. *New Ideas in Psychology, 32,* 147-157. DOI: 10.1016/j.newideapsych.2013.03.005

Gibson, J, J. (1979). *The ecological approach to visual perception*. Boston: Houghton-Mifflin

Gosling, S.D., Rentfrow, P.J., & Swann Jr., W.B. (2003). A very brief measure of the Big-Five personality domains. *Journal of Research in Personality*, *37*(6), 504-528. DOI: 10.1016/S0092-6566(03)00046-1

Greenwald, A.G. & Banaji, M.R. (1995). Implicit social cognition: Attitudes, self-esteem, and stereotypes. *Psychological Review, 102*(1), 4-27. DOI: 10.1037/0033-295X.102.1.4

Gueguen, N. & Martin, A. (2009). Incidental similarity facilitates behavioral mimicry. *Social Psychology, 40*(2), 88-92. DOI: 10.1027/1864-9335.40.2.88

Gunns, R.E., Johnston, L., & Hudson, S.M. (2002). Victim selection and kinematics: A point-light investigation of vulnerability to attack. *Journal of Nonverbal Behavior, 26*(3), 129-158. DOI: 10.1023/a: 1020744915533

Heider, F. (1958). *The Psychology of Interpersonal Relations.* Lawrence Erlbaum Associates, Inc.: Hillsdale, New Jersey

Hodges, B.H. & Baron, R.M. (2007). On making social psychology more ecological and ecological psychology more social. *Ecological Psychology, 19*(2), 79-84. DOI: 10.1080/10407410701331918

Hove, M.J. & Risen, J.L. (2009). It's all in the timing: Interpersonal synchrony increases affiliation. *Social Cognition, 27*(6), 949-960. DOI: 10.1521/soco.2009.27.6.949

Johansson, G. (1973). Visual perception of biological motion and a model for its analysis. *Perception and Psychophysics, 14*(2), 201-211. DOI: 10.3758/BF03212378

Johnson, K.L. & Tassinary, L.G. (2005). Perceiving sex directly and indirectly: Meaning in motion and morphology. *Psychological Science, 16*(11), 890-897. DOI: 10.1111/j.1467-9280.2005.01633.x

Kenny, D.A. (2004). PERSON: A general model of interpersonal perception. *Personality and Social Psychology Review, 8*(3), 265-280. DOI: 10.1207/s15327957pspr0803_3

Kouzakova, M., Karrenmans, J.C., van Baaren, R.B., & van Knippenberg, A. (2010). A stranger's cold shoulder makes the heart grow fonder: Why not being mimicked by a stranger enhances longstanding relationship evaluations. *Social Psychological and Personality Science, 1*(1), 87-93. DOI: 10.1177/1948550609355718

Kozlowski, L.T. & Cutting J.E. (1977). Recognizing the sex of a walker from a dynamic point-light display. *Perception and Psychophysics, 21*(6), 575-580. DOI: 10.3758/BF03198740

Lakin, J.L. & Chartrand, T.L. (2003). Using nonconscious behavioral mimicry to create affiliation and rapport. *Psychological Science, 14*(4), 334-339. DOI: 10.1111/1467-9280.14481

Lakin, J.L., Jefferis, V.E., Cheng, C.M., & Chartrand, T.L. (2003). The chameleon effect as social glue: Evidence for the evolutionary significance of nonconscious mimicry. *Journal of Nonverbal Behavior, 27*(3), 145-162. DOI: 10.1023/A:1025389814290

Lumsden, J., Miles, L.K., & Macrae, C.N. (2012). Perceptions of synchrony: Different strokes for different folks? *Perception, 41*(12), 1529-1531. DOI: 10.1068/p7360

Lumsden, J., Miles, L.K., Richardson, M.J., Smith, C.A., & Macrae, C.N. (2012). Who syncs? Social motives and interpersonal coordination. *Journal of Experimental Social Psychology, 48*(3), 746-751. DOI: 10.1016/j.jesp.2011.12.007

Macrae, C.N., Duffy, O.K., Miles, L.K., & Lawrence, J. (2008). A case of hand waving: Action synchrony and person perception. *Cognition, 109*, 152-156. DOI: 10.1016/j.cognition.2008.07.007

Macrae, C.N. & Quadflieg, S. (2010). Perceiving people. In S.T. Fiske, D.T. Gilbert, & G. Lindzey (Eds.), *Handbook of Social Psychology Volume II* (p. 428-463). Hoboken, New Jersey: John Wilkey & Sons.

Marsh, K. L., Richardson, M. J., & Schmidt, R. C. (2009). Social connection through joint action and interpersonal coordination. *Topics in Cognitive Science*, *1*, 320-339. DOI: 10.1111/j.1756-8765.2009.01022.x

Mather, G. & Murdoch, L. (1994). Gender discrimination in biological motion displays based on dynamic cues. *Proceedings: Biological Sciences, 258*(1353), 273-299. DOI: 10.1098/rspb.1994.0173

McDonnell, R., Jorg, S., Hodgins, J.K., Newell, F., & O'Sullivan, C. (2007). Virtual shapers & movers: Form and motion affect sex perception. *ACM International Conference Proceeding Series, 253*, 7-10; 153. DOI: 10.1145/1272582.1272584

Miles, L.K. (2008). Who is approachable? *Journal of Experimental Social Psychology, 45*, 262-266. DOI: 10.1016/j.jesp.2008.08.010

Miles, L.K., Griffiths, J.L., Richardson, M.J., & Macrae, C.N. (2010). Too late to coordinate: Contextual influences on behavioral synchrony. *European Journal of Social Psychology, 40*, 52-60. DOI: 10.1002/ejsp.721

Miles, L.K., Lumsden, J., Richardson, M.J., & Macrae, C.N. (2011). Do birds of a feather move together? Group membership and behavioral synchrony. *Experimental Brain Research, 211*(3-4), 495-503. DOI: 10.1007/s00221-011-2641-z

Miles, L.K., Nind, L.K., & Macrae, C.N. (2009). The rhythm of rapport: Interpersonal synchrony and social perception. *Journal of Experimental Social Psychology, 45,* 585-589. DOI: 10.1016/j.jesp.2009.02.002

Miles, L.K., Nind, L.K., Henderson, Z., Macrae, C.N. (2010). Moving memories: Behavioral synchrony and memory for self and others. *Journal of Experimental Social Psychology, 46*, 457-460. DOI: 10.1016/j.jesp.2009.12.006

Montepare, J.M. & Zebrowitz-McArthur, L. (1988). Impressions of people created by age-related qualities of their gaits. *Journal of Personality and Social Psychology, 55*(4), 547-556. DOI: 10.1037/0022-3514.55.4.547

Oullier, O., de Guzman, G.C., Jantzen, K.J., Lagarde, J., & Kelso, J.A.S. (2008). Social coordination dynamics: Measuring human bonding. *Social Neuroscience, 3*(2), 178-192. DOI: 10.1080/17470910701563392

Paxton, A. & Dale, R. (2014). Argument disrupts interpersonal synchrony. *The Quarterly Journal of Experimental Psychology, 66*(11), 2092-2102. DOI: 10.1080/17470218.2013.853089

Richardson, M.J., Harrison, S.J., Kallen, R.W., Walton, A., Eiler, B.A., Saltzman, E., & Schmidt, R.C. (2015). Self-organized complementary joint action: Behavioral dynamics of an interpersonal collision-avoidance task. *Journal of Experimental Psychology: Human Perception and Performance, 41*(3), 655-679. DOI: 10.1037/xhp0000041

Richardson, M. J., Marsh, K. L., & Schmidt, R. C. (2010). Challenging egocentric notions of perceiving, acting, and knowing. In L. F. Barrett, B. Mesquita, and E. Smith. (Eds.). *The Mind in Context*. (pp. 307-333). New York, NY: Guilford.

Riley, M.A., Richardson, M.J., Shockely, K., & Ramenzoni, V.C. (2011). Interpersonal synergies. *Frontiers in Psychology, 2*(38), 1-7. DOI: 10.3389/fpsyg.2011.00038

Runeson, S. & Frykholm, G. (1983). Kinematic specification of dynamics as an informational basis for person-and-action perception: Expectation, gender recognition, and deceptive intention. *Journal of Experimental Psychology: General, 112*(4), 585-615. DOI: 10.1037/0096-3445.112.4.585

Schmidt, R.C., Nie, L., Franco, A., & Richardson, M.J. (2014). Bodily synchronization underlying joke telling. *Frontiers in Human Neuroscience, 8*, 633. DOI: 10.3389/fnhum.2014.00633

Schmidt, R.C. & O'Brien, B. (1997). Evaluating the dynamics of unintended interpersonal coordination. *Ecological Psychology, 9*(3), 189-206. DOI: 10.1207/s15326969eco0903_2

Schmidt, R. C., & Richardson, M. J. (2008). Dynamics of Interpersonal Coordination. In A. Fuchs & V. Jirsa (Eds.). *Coordination: Neural, Behavioral and Social Dynamics*. (pp. 281-308). Heidelberg: Springer-Verlag.

Smedley, A. & Smedley, B.D. (2005). Race as biology is fiction, racism as a social problem is real: Anthropological and historical perspectives on the social construction of race. *American Psychologist, 60*(1), 16-26. DOI: 10.1037//0003-066X.60.1.16

Sumi, S. (2000). Perception of point-light walker produced by eight lights attached to the back of the walker. *Swiss Journal of Psychology, 59*(2), 126-132. DOI: 10.1024//1421-0185.59.2.126

SurveyGizmo (2015). [Online Data Collection Software]. Boulder, Colorado: Widgix, LLC. Retrieved from http://www.surveygizmo.com

Troje, N. (2002). The little difference: Fourier based synthesis of gender-specific biological motion. In R.P. Würtz & M. Lappe (Eds.), *Dynamic Perception* (pp. 115-120). Berlin: AKA Press.

Turvey, M.T. (1990). Coordination. *American Psychologist, 45*(8), 938-953. DOI: 10.1037/0003-066X.45.8.938

Vacharkulksemsuk, T. & Fredrickson, B.L. (2012). Strangers in sync: Achieving embodied rapport through shared movements. *Journal of Experimental Social Psychology*, *48*(1), 399-402. DOI: 10.1016/j.jesp.2011.07.015

van Leeuwen, M.L., Veling, H., van Baaren, R.B. & Dijksterhuis, A. (2009). The influence of facial attractiveness on imitation. *Journal of Experimental Social Psychology, 45*(6), 1295-1298. DOI: 10.1016/j.jesp.2009.07.008

Van Orden, G.C. (2010). Voluntary performance. *Medicina (Kaunas), 46*(9), 581-594.

Van Orden, G.C., Kloos, H., & Wallot, S. (2011). Living in the pink: Intentionality, wellbeing, and complexity. In D.M. Gabby, P. Thagard, & J. Woods (Eds.), *Philosophy of Complex Systems* (pp. 629-672). North Holland: Oxford, U.K.

Van Swol, L.M. & Drury, M. (2006) *The effects of shared opinions on mimicry.* Paper presented at International Communication Association Annual Conference.

Warren, W.H. (1984). Perceiving affordances: Visual guidance of stair climbing. *Journal of Experimental Psychology: Human Perception and Performance, 10*(5), 683-703. DOI: 10.1037/0096-1523.10.5.683